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(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 402 553 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 89600024.7

(51) Int. Cl.5: A61M 5/145, F16H 25/24

(22) Date of filing: 27.11.89

(30) Priority: 15.06.89 GR 89010400

(43) Date of publication of application:
19.12.90 Bulletin 90/51

(84) Designated Contracting States:
DE FR GB

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(54) Syringe pump.

(57) A syringe pump with a motor and an externaly threaded Drive Rod (1), with a special type of mechanical Drive unit (2, 3, 4), that the main Drive unit has no deterioration at all at an engagement disengagement procedure, and that a pressure transducer placed at just in tuch with the syringe's plunger deducts information on the pressure inside the syringe mathematically and whereas a safe connector type indicator indicates to both system microprocessor and the user the syringe type used.

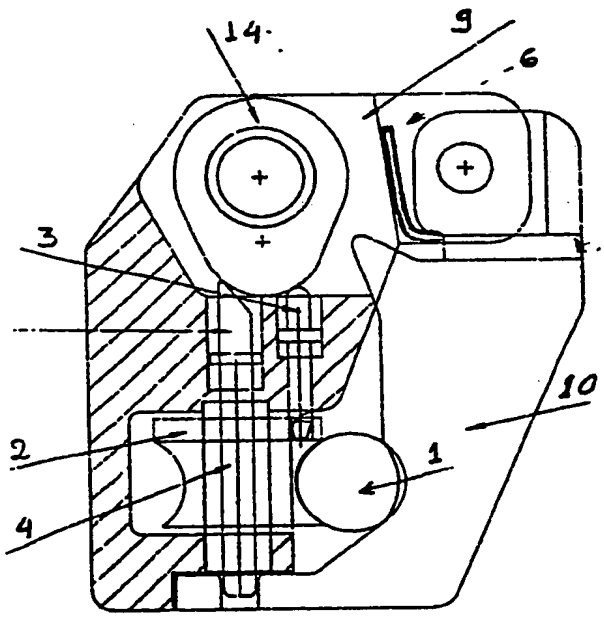

Fig 3

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SYRINGE PUMP

This invention relates to a syringe type infusion pump i.e. drive unit for effecting precise operation of a syringe.

In modern therapy, several liquids need to be infused into the body at a controled rate. Several types of infusion pumps have been developed, one of them named syringe pump consisting of a mechanism pushing a syringe's plunger and administering liquid via a catheter to the body.

Such a pump must fulfil the following recomendations especially if it is to be used also for parenteral (or intravenus) administration: Be precise and safe, be rudged and wear out resistant, be easy to use, control pressure of infused liquid under precise low and high limits, be adjustable for rates and for syringes of different brands by a safe, error-free mechanism. It is the aim of the present invention to provide improvements in several technological solutions concerned by theese recomendations.

As a syringe pump, using an externally screw-threaded drive rod as driving principle, has to provide the facility to push the syringe's plunger in normal operation, but also to let the pushing member be placed freely behind the plunger by an engage-disengage-engage procedure of the driving mechanism and the drive rod, the known mechanisms fail to fulfil the wear out resistant recomendation. At the time that the syringe has a back force due to venal or arterial pressure or to an occlusion, a disengagement of the pushing member for changing the syringe, disengages the driving half nuts which receive a tangential force that damages the half nuts as they move out of engagement with the drive rod, passing over several threads of the lead screw before they are at least disengaged. The same damage is encountered if one engages the mechanism while moving the pushing member, the only braking mechanism being the nuts themselves. At least one proposal exists that uses speedy disengagement as a remedy, which lessens but not eliminate the problem. The idea expressed by the present invention is to improve the reliability of the driving system, using a brake, so that the half nuts are engaged or disengaged only in a relative stationary system, with no damage, as the three functions half nut engage, brake, lock, are done by a precise sequence in each engage-disengage-engage procedure. This brake is used in conjuction with the property of a crown wheel to roll over an externaly screw-threaded drive rod, transformed if braked, to a half nut.

As a syringe pump preferably has to signal an alarm for high limit of pressure inside the syringe's barel, and also for low pressure which indicates a misplacement of the canula, a sensor has to be placed at some location. The direct on the fluid method needs special type of catheter as a disposable, with a soft membrane part, which is not economical against the standard one. Another known method is to sense the pressure through a strain gauge placed near the motor, thus sensing trough the total system friction from the syringe's plunger to the motor, passing by at least three friction parts. In the known inventions, using smaller than the calibrated syringe in diameter, can make the pump exceed the high pressure limits by a large extend. By the present invention, the sensing element is placed right on the pushing member, just in touch with the syringe's plunger. No pump's friction member is placed in between. An analog to digital converter gives a direct reaction force measurement and pressure is calculated by the system microprocessor by the relation $P = C1 \cdot F/S + C2$ where P stands for pressure, C1 and C2 calibration factors for each syringe type, F for A/D reading, S for used syringe's cross sectional area. It is apparent that by the present invention any syringe type has the same safe pressure limits.

As a syringe pump preferably has to be able to adapt for different syringes, a safe label-digital input set for each syringe has to be used so that accidental use of different setting be eliminated. In the known pumps, a BCD of Hexadecimal switch is used which can be readjusted from one nurse to the next, leading to errors of use. In the present invention, a special type of plug having redundand (for safety) bridged leads selectively for each syringe type, is used as digital input information to the processor and having a large, colored in different background-letter combinations labeling area, so that safety is improved by making any change pass through an authorized person who holds the connectors and by clearly labelling each change.

DESCRIPTION OF THE PREFERED EMBODIMENT

Refering to the drawings for purpose of ilustrating the presently prefered embodiment of the new infusion pump of the present invention, FIG1 presents an external view of the pump, FIG2 the plug type syringe selector, FIG3, FIG6, FIG7, FIG8 phases of engagement of the mechanism with a crown wheel and half nut plus brake and locking, FIG4 a side view of the same, FIG5 presents a

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double crown wheel plus brake alternative implementation.

The prefered embodiement consists of a casing, on this casing multiple keyboard and multiple displays FIG1/13, alarm indicators, cover for syringe retention FIG1/12, inside the casing a motor FIG4/18 drivably connected with an externally screw-threaded drive rod FIG4/1. The rotation of the motor is translated to linear movement via half nut 5 and crown wheel 2 to moving rods 7 and 11, which slide over rod 8. Rod 7 is fixed at one end to the stable part of the pushing member 17, at the other end fixed to the retaining the crown wheel part 9, which is adjascent to the wall of the casing in a way that it cannot rotate around the rod 8 which means that member 17 does not rotate either. On member 17 and in touch with the syringe's plunger is placed linear force sensor assembly 16. Rod 11 is at one end fixed to the member 15 which rotates in a way that holds or releases the end of the syringe's plunger, passing over member 17. At the other end, rod 11 is fixed to the cam FIG3/14, which rotates together with member 15. Part 10 together with part 9 form a staple over driving rod 1, spring 6 tending to push them against rod 1, stoped by their form in a way that no vertical force is exercised on rod 1, being just in close tolerance engaged with it. Lock 4 is used for said staple not to open if eccessive force is exercised in the driving rods and making spring 6 be of not critical torque value, as well as being weaker than if its function were to hold parts 10 and 9 in driving engagement with rod 1. Brake 3 is used to stop crown wheel 2 rolling, transforming it to a half nut in function, so that an engagement or disengagement of the main driving half nut 5 be done in a relative stationary system i.e. regardless if the motor is runing or not, as the threads of half nut 5 and crown wheel 2 are synchronised by the holes along crown wheel's side where brake 3 enters, each hole being a stable location for each discrete possible match of threads of half nut 5 and lead screw 1. With this system it is aparent that no damage of main half nut 5 is possible, where brake 3 itself has low damage as it is designed for such a braking function. Crown wheel 2 is of nonstandard thread, having many deep threads engaged with the drive rod 1, designed to hold by itself alone the relatively high loads that a hand can exerce on. This system improves life expectancy of the infusion pump, as electronics being very reliable, the weakest part of the previus designs being the driving half nuts, clipped out by the engagement-disengagement procedure.Cam 14 rotating, enduces the folowing sequence of functions in the disengagement procedure: FIG3 full engaged system with lock in, brake in, half nut 5 engaged, translating rotation to linear movement. FIG6 lock out. FIG7 half nut 5 disengaged. FIG8 brake out, free linear travel. The inverse is done for the engagement procedure for a sequence FIG8,FIG7,FIG6,FIG3.

Cam 14 when completely rotated for free run, is blocked by the protruding member of part 10 so that it finds a second stable position FIG.8.

In FIG5, another implementation of the same braking principle in conjunction with the crown wheel is ilustrated, where two crown wheels in fixed position on each side of the driving rod, roll over it at disengagement and are braked through cam rotation at engagement, thus being transformed functionaly to half nuts.

In the present invention there are no sliding parts (when at run) over the casing, but the two journal bearings at the ends of rods 7 and 11 with calibre rod 8 and their penetrating the casing journal bearing, inducing in minimal and smoothest friction along the travel, which means minimal oscillations of the self adapting P.I.D. control of the DC Motor.

Signal of the strain gauge 16 is transfered trough rods 7 and 11, who form a coaxial like cable, down to part 9 which at its side has also a magnetic or optic sensor for absolute position reading in accordance with an adhequate strip along the casing. Any type of swich is used for sensing if parts 9 and 10 are locked. Signals of swich, encoder and force sensor are transfered to a safe system of microprocessors through a flexible cable. Motor has fixed on its rotor a magnetic drum and hall effect sensors that are used as tachogenerators. Its current is limited, so that a fault in the pressure transducer will not make the pump exceed the maximum allowed pressure limits.

In FIG2 the plug type syringe selector 19 is illustrated, where a bicolored label 20 signals the used syringe's brand name and volume , having different sets of colors for the different combinations of syringes, and where the plug's pins are internaly selectively bridged for giving a digital information on the syringe used to the microprocessor. Two redundand sets of said briged pins are used for safety.

Claims

1. A syringe pump which comprises:
   (a) a casing;
   (b) within said casing a motor;
   (c) a lead screw connected to said motor so that, in use, the motor can rotate the leads about its axis, the other end of said lead screw being free to rotate in a journal bearing;
   (d) a safe multiple microprocessor system that is aranged to communicate with keyboard, display, motor, sensors for posision control, sen-

sors for motor speed determination, sensors for safety of operation.

2. A syringe of a lead screw pump that uses friction part or parts for translating rotation to linear movement, hereinafter named friction translators, and part or parts for braking said friction translators hereinafter named brakes, their function being to immobilise the relative position of friction translators against the thread patern of the externaly screw-threaded drive rod, even if it is rotating, during engagement and disengagement, so that friction translators are not damaged by an engagement or disengagement procedure, where engagement is the position that only rotation of lead screw induces linear movement proportionally, and where disengaged posision, is the position that linear movement is free, and that said brakes and only them subit any wear out from the engagement to disengagement and from disengagement to engagement procedure, the friction translators being weared out only from the rotation to linear movement translation procedure.

3. A syringe pump as claimed in claim 1 or 2, wherein said friction translators comprise at least one crown wheel and a half nut.

4. A syring pump as claimed in claim 3, wherein said brake, brakes the crown wheel, which is always in touch with the externaly screw-threaded drive rod, thus not allowing it to roll over the drive rod, in discrete positions that are the correct match of the threads of the half nut and those of the drive rod, braking being effective at least during engagement and disengagement of the half nut, brake being released after disengagement for free linear movement.

5. A syringe pump as claimed in claim 4, whereas brake is effective during normal infusion, whereas crown wheel transmits power as a normal half nut.

6. A syringe pump as claimed in claim 4 or 5, where the suports of crown wheel and half nut are locked together in a way that they are attached steedily against lead screw during normal infusion.

7. A syringe pump as claimed in claims 4,5 or 6, where the supports of the crown wheel and half nut opened for free run, remain opened by a bistable structure until closed by opposite hand action.

8. A syringe pump as claimed in claims 1 or 2, whereas friction translators are crown wheels around the externaly screw-threaded drive rod, that roll over it at free run, or disengaged position, and braked by action on their axis, for engagement, or normal infusion, acting as normal half nuts transmitting power.

9. A syringe pump as claimed in any preceding claim, whereas the reaction of the syringe's plunger is sensed by an analog sensor placed at the pushing member of the mechanism, just behind the syringe's plunger, the pressure of the liquid inside syringe being calculated in real time by the microprocessor by the formula $P = C1 \cdot F \cdot S + C2$ where P stands for pressure, C1 and C2 for specific syringe's calibration factors, S for same syringe's cross sectional area, F for reading number of the sensor transduced to digital form.

10. A syringe pump as claimed in any preceding claim, wherein a plug type indicator is provided to indicate to both the user and system microprocessor the syringe type used, and wherein information to the microprocessor is communicated by means of redundant pins, for safety,selectively bridged inside the body of the plug-indicator and epoxied so that no fault outside the factory can be done, and wherein information to the user is provided by means of a bicolored label, each syringe type dedicated to a pair of colors.

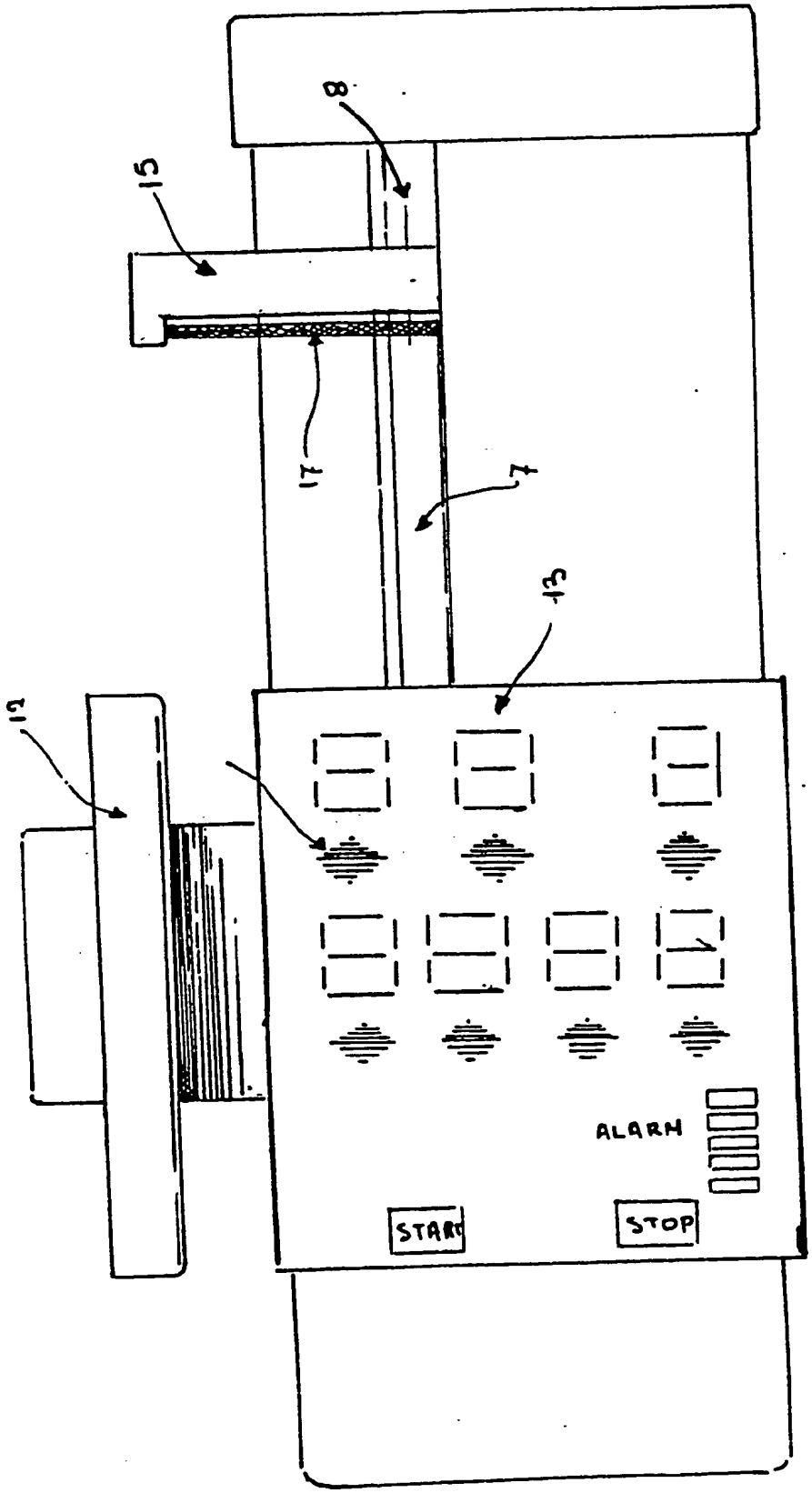

FIG 1

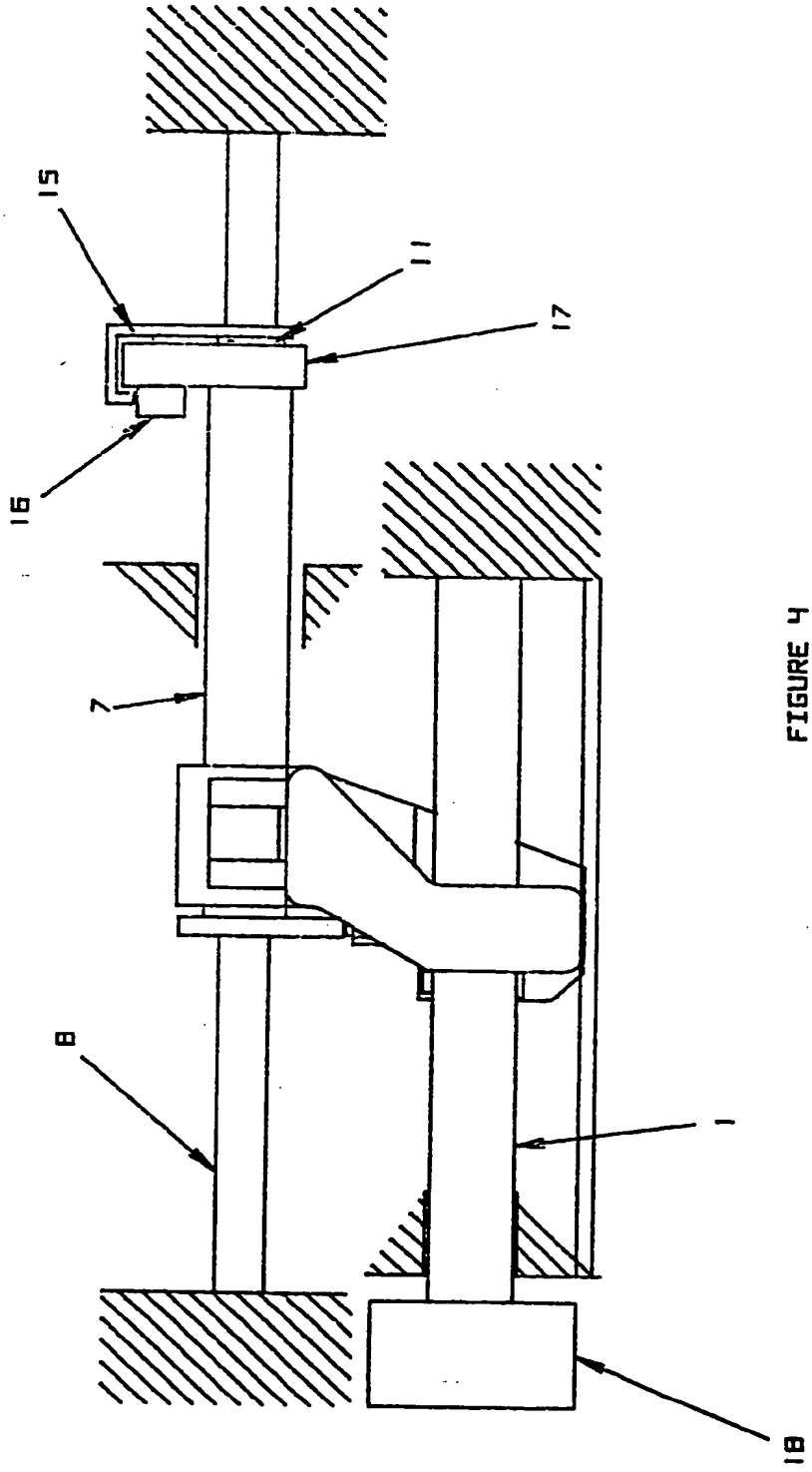

FIGURE 4

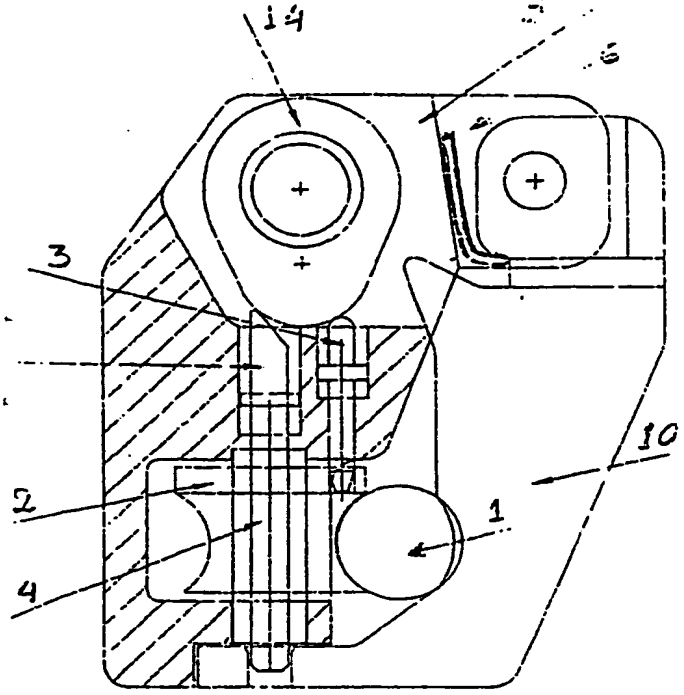

Fig 3

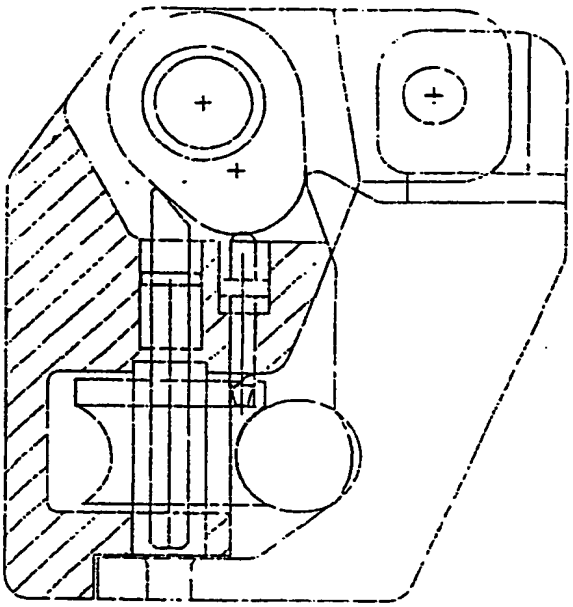

Fig 6

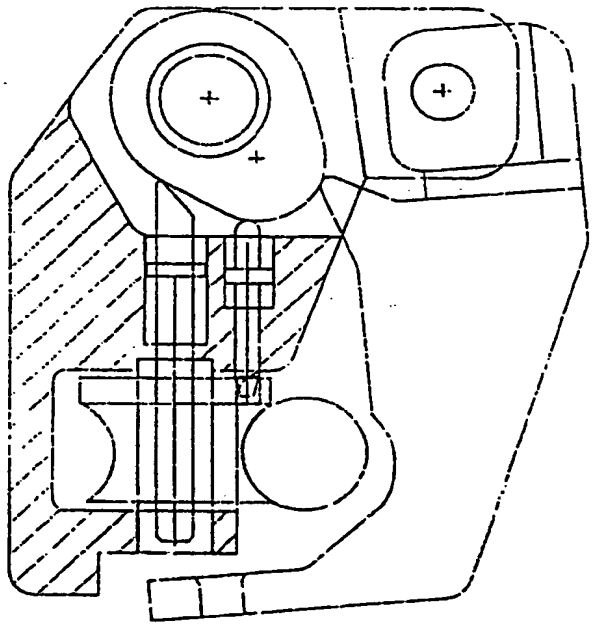

Fig 7

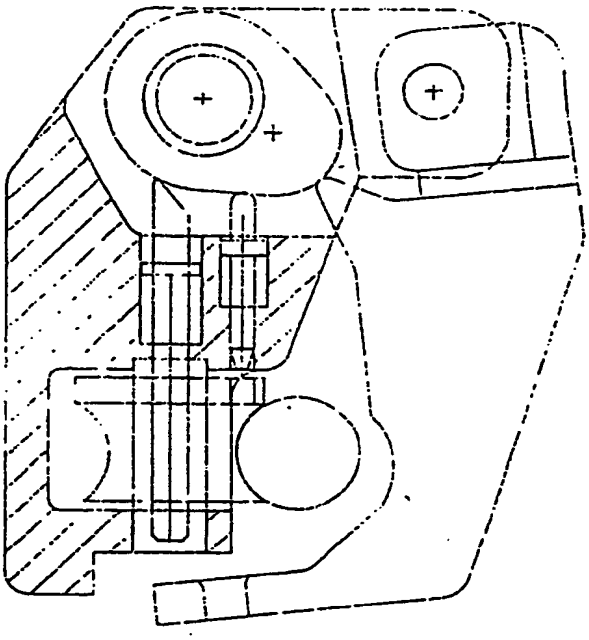

Fig 8

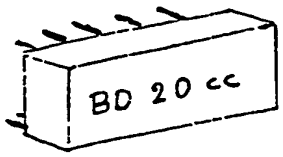

Fig 2

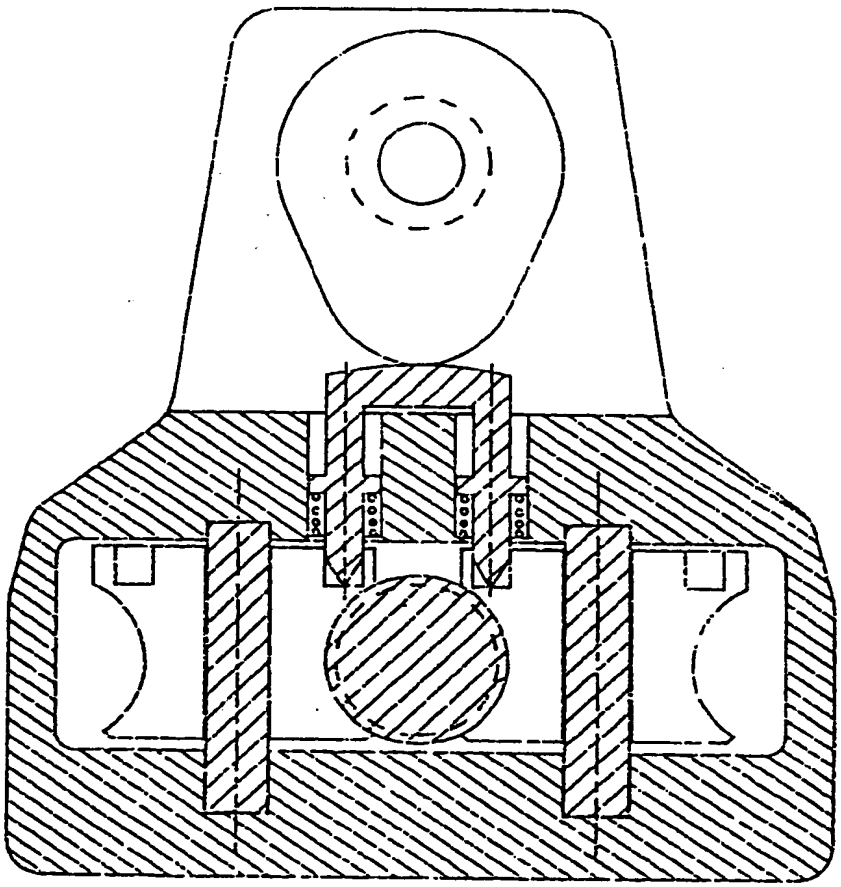

Fig 5

European Patent Office

EUROPEAN SEARCH REPORT

Application number
EP 89 60 0024

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int Cl 4)
X	US-A-4 838 857 (STROWE et al.) * Claims 1,4-7,10,11; figures *	1	A 61 M 5/145B F 16 H 25/24
Y	US-A-4 563 175 (LAFOND) * Column 3, line 39 - column 7, line 7; figures *	1,2,8	
Y	EP-A-0 204 977 (INTELLIGENT MEDICINE) * Claims 1,5,6,15; figure 13 *	1	
X	GB-A-2 166 497 (INFORS GmbH) * The whole document *	2	TECHNICAL FIELDS SEARCHED (Int Cl 4) A 61 M F 16 H
A		3-6	
Y	DE-A-1 750 562 (KITTSTEINER) * Page 1, line 31 - page 2, line 37; figures 1,2 *	2,8	
A		3-6	

~~The present search report has been drawn up for all claims~~

Place of search	Date of completion of the search	Examiner
THE HAGUE	23-04-1990	CLARKSON

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

☐ All claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for all claims.

☐ Only part of the claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid.

namely claims:

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

x LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions.

namely:

1. Claims 1-8: Syringe pump with means for dis/-engaging drive spindle and plunger actuator.

2. Claims 1,9: Pressure sensor for syringe driver (a posteriori).

3. Claims 1,10: Plug in indicator for signalling type of syringe used (a posteriori).

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid.

namely claims:

☒ None of the further search fees has been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims.

namely claims: 1-8

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EUROPEAN SEARCH REPORT

Application number

EP 89 60 0024

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	FR-A-2 518 410 (INTERMEDICAT) * Page 7, line 5 - page 9, line 9; figures *	2	
A		1	

			TECHNICAL FIELDS SEARCHED (Int. Cl.4)

Place of search	Date of completion of the search	Examiner

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